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Preliminary Description of the New Photographic Equatorial of the Cambridge Observatory. By Sir Robert Ball, Director of the Observatory.

There has recently been added to the equipment of the Cambridge Observatory a photographic equatorial of novel design, which is so bold a departure from the ordinary forms that it seems well to give a prompt preliminary description of it pending the appearance of a detailed description in the publications of the Observatory.

The essential features of the plan were proposed so long ago as 1884 by Sir Howard Grubb in a paper in the *Phil. Trans. R. Dubl. Soc.* (vol. iii. series 2, p. 61). The instrument is a *coudé* telescope, but of a different type from the *Équatorial Coudé* of M. Lœwy. A long and heavy tube is mounted on bearings top and bottom, so that its axis of rotation is the polar axis of the instrument. Towards its lower end is carried the declination axis, and upon this axis turns a short tube carrying the object-glass. Upon an axis concentric with the declination axis is carried a plane mirror, which is geared so as always to bisect the angle between polar axis and objective tube. If, then, the objective tube is directed to any star, the convergent beam from the object-glass is received by the plane mirror, reflected up the polar tube, and brought to a focus at the upper end of the tube. The observer remains in a fixed position, looking down the polar tube from the top. If, then, the polar tube is carried up into a closed room, while the rest of the instrument is mounted under a cover, which can be moved right away, leaving it in the open air, the observer can work in a closed and comfortably warmed room, and can from it command any part of the sky within range of the instrument without the continual trouble of moving dome and shutters.

This form of *coudé* has the advantage over that of M. Lœwy that only one plane mirror is required instead of two. It has, of course, on the other hand, the disadvantage that the regions close to the pole are cut off by the building. It has the advantage over all forms of fixed telescope fed by a heliostat or cœlostat that the angle of incidence on the plane mirror does not alter during the exposure on a given object, though it is different for objects of different declinations.

While the observatory syndicate was discussing the question of building a photographic equatorial a letter was received from Professor Turner and Dr. Common bringing to their notice the advantages of this new form of equatorial, and urging them not to neglect the opportunity, which so rarely presents itself, of building a large instrument upon original lines. This proposal was favourably entertained by the syndicate, and the plans for the new instrument were prepared by Sir Howard Grubb.

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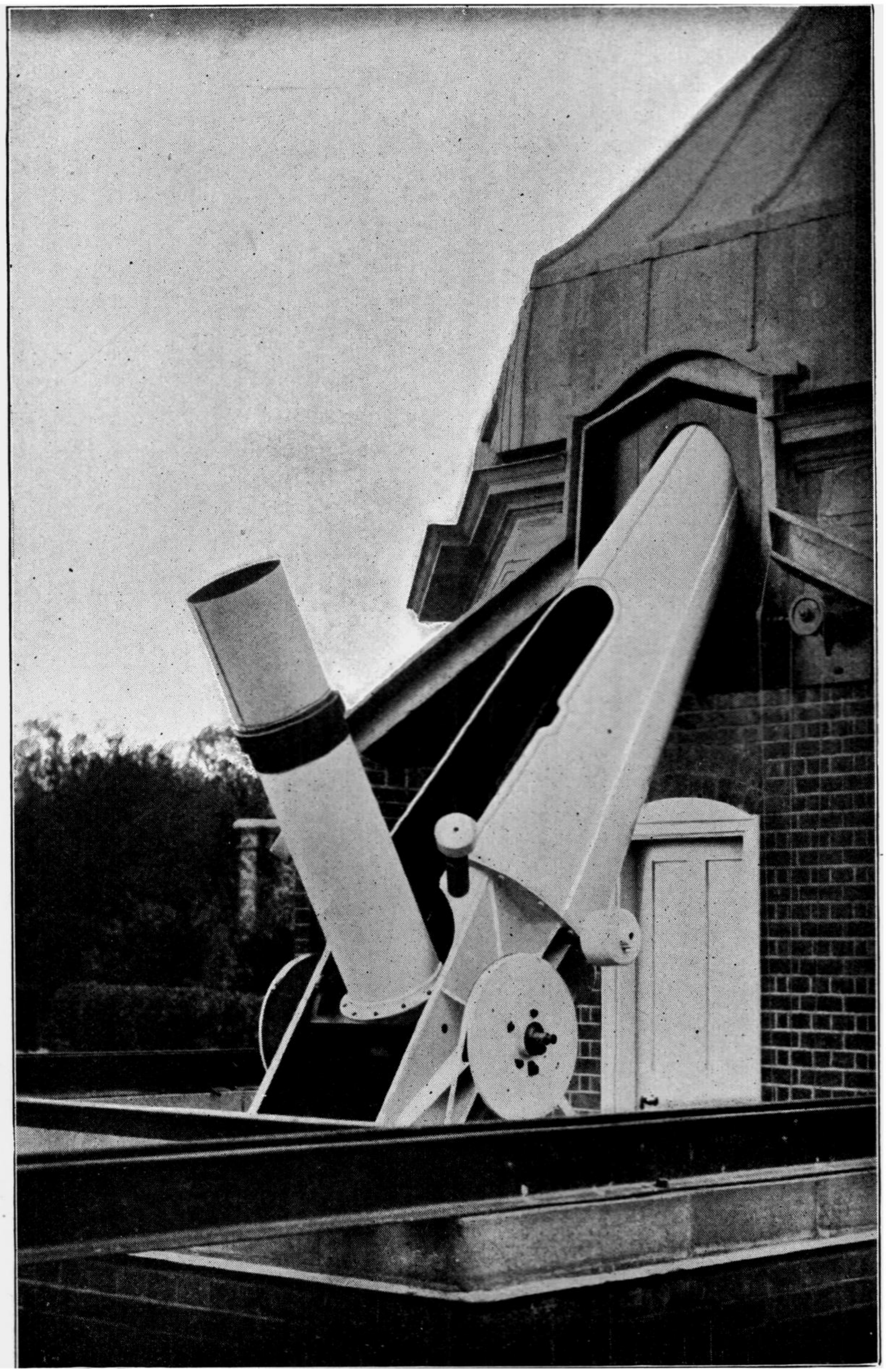

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The building in which the telescope is installed was designed by Mr. T. D. Atkinson, architect, of Cambridge. The main part of it is of red brick, square, placed with a diagonal in the meridian, with the south corner flattened. To the south of the main building, and adjoining it, a low wall encloses a rectangular floor. Along the top of the wall rails are laid, and are carried forty feet to the south on brick piers. Upon this railway runs a light house, a skeleton of iron covered with papier-mâché.

The upper and lower bearings of the polar axis rest upon very massive concrete piers, the tall one for the upper bearing just inside the flattened south corner of the main building, the short one for the lower bearing near the southern end of the enclosure which is covered by the running house. The piers are carried down through the foundations of the building, separated from them by a sand joint, and rest upon an excellent foundation of hard blue gault clay.

The heavy conical polar axis tube passes through the wall of the main building to its upper bearing upon the tall pier. When the running house is closed its north end makes a weather-tight joint with the building above the point where the polar tube passes through the wall. The instrument is then completely protected from the weather.

The running house is opened and closed by a chain which passes round a winch at the south end of the railway. It runs quite easily, and can be wound away to the end of the railway in about a minute.

On the ground floor of the building is a large photographic dark room. A doorway under the tall arched pier leads into the running house. A staircase leads upstairs to the observing room, whose high pitched roof, covered with lead, is designed to cut off as little sky as possible from the instrument.

In the south corner of the observing room the tall concrete pier comes up to the level of the floor, and is capped by a large block of stone. To this is bolted the large casting which carries the V bearing for the upper end of the polar axis, the driving clock, automatic electric control, and gearing for the driving sector.

With this form of instrument it is, of course, impossible to reach to the pole. The roof of our building begins to cut off light from the object-glass when the instrument is set on the meridian to decl. 75° N. To allow the objective tube to be turned so far north it was necessary to cut away very considerably the polar tube, as the photograph shows. And a correspondingly large piece had to be cut out of the objective tube, which would otherwise have intercepted a portion of the light after reflection from the mirror. This cutting away of the objective tube is undoubtedly a source of weakness. Had we been content to sacrifice all the sky within 30° of the pole, scarcely any cutting away of the objective tube would have been required. As it is, it will be necessary to devise a self-adjusting covering of some flexible material to cover the large opening which is left when the

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instrument is turned to the south. We have not, up to the present, arrived at a satisfactory solution of this problem.

The object glass, by Messrs. Cooke & Son, of York, has an aperture of 12½ inches and a focal length of 19·3 feet. It is one of their new triple photo visual combinations (H. D. Taylor's patent).

The objective tube is bolted to a square box which is carried on the declination axis. To the east side of this box is screwed the declination circle; and on the west side is a crown wheel which engages in a pinion on the end of a rod which is carried up to the eye end, and geared to a hand wheel. This provides for the quick motion in declination. Rods which actuate the clamp and slow motion in declination are also carried up to the eye end.

Inside the square declination box is the mirror box, which turns on an axis concentric with the declination axis. At each end of the mirror axis is a large drum, and inside these, on the ends of the declination axis, are similar drums of half the diameter of the outer ones. Flexible steel tapes are carried in opposite directions off the mirror drums, round pulleys, and on to the declination drums. When these tapes are tightened the mirror axis is thus firmly connected with the declination axis, and the mirror is constrained to move in declination at half the rate of the objective tube. If, then, when the objective is turned into the polar tube until their axes coincide, the mirror is set normal to these axes, it will in all positions bisect the angle between the objective and polar tubes. We are indebted for the mirror to the generosity of Dr. Common.

The adoption of a *coudé* form for a photographic telescope involves almost necessarily the adoption of the principle of guiding by a star on the edge of the field, just off the edge of the plate. Dr. Common has also kindly lent us for our instruction and imitation an apparatus which he had made on this principle, and has described in the *Monthly Notices* (vol. xlv. p. 25). The plate-holder and the guiding eyepiece, which can be moved with reference to the plate-holder in one coordinate, are carried upon a double slide, movable in two directions at right angles to one another by two screws with large milled heads. Corrections to the guiding in either coordinate can thus be given without disturbing in any way the driving of the telescope, or making use of the slow motion of the objective tube in declination.

The driving clock and automatic electric control are of Sir Howard Grubb's standard pattern, with the exception of the controlling pendulum, which is not electrically driven, but swings freely.

The hour circle, just above the upper bearing, is read directly by the reading telescope at the eye end; and by means of a system of reflecting prisms and lenses in an elbowed tube, which can be turned into the axis of the same telescope, the declination

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circle at the lower end of the polar tube upon the declination axis can be read.

It is impossible to speak at present of the performance of the new instrument. The non-reversibility, the introduction of the mirror, and the impossibility of getting at the pole have led to some difficulties in the adjustment. A description of them must be deferred. But it is, perhaps, allowable to say now that everything seems to promise well for the success of the new form.

For much of the design and for constant assistance at every stage of the work we are indebted to Mr. Newall, and I must also add that Mr. Hinks has given incessant attention to the carrying out of the details of the building and the erection of the instrument.

Note on the Exterior Nebulosities of the Pleiades.

By E. E. Barnard.

These nebulosities, shown on two plates taken by me with the Willard lens in 1893, have been amply verified (if such a verification were at all necessary).

These plates were given exposures of 4 hours and 10¼ hours. The nebulosities are shown on both plates, but, of course, best on the longer exposure. (See *Monthly Notices*, lvii. pp. 10–16.)

I have lately seen two other photographs that show these nebulosities distinctly.

The first of these was made with a 6-inch portrait lens by Dr. H. C. Wilson, of Northfield, Minn., with 11 hours' exposure, which shows the nebulosities even more distinctly, in some respects, than they are shown on my plates.

While at Harvard College Observatory this summer I was shown a fine photograph of the *Pleiades* by Professor S. I. Bailey, which was taken by him in 1897 October with an 8-inch doublet at Arequipa with an exposure of 5 hours. This plate shows all these exterior nebulosities better than they are shown on my 4-hour plate, but not so well as with the 10-hour exposure.

It would therefore appear that a failure to show these remarkable features with an ordinary portrait lens and an exposure anything like 4 or 5 hours must be attributed to something else than their non-existence.

Yerkes Observatory, Williams Bay, Wis.:
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